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DAYLIGHT OBSERVATIONS ON VENUS

BY

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One day during the summer of 1908, while on a magnetic surveying trip in northern Canada, I was lying back in the canoe as we were sailing across one of the numerous lakes of that region, and gazing up into the brilliant blue of the sky, when suddenly I was astonished to find my attention fixed by a very bright star shining in the western heavens. Never before had I seen Venus with the unaided eye in bright sunlight, and it appeared so brilliant and so prominent that, with a little directing, it was soon located by all the members of the party.

As I had had some experience in navigation, the star's brightness and visibility at once impressed me with its possible use as an object for observation, in connection with observations on the sun, to determine the position of a ship at sea. Since that time I have been curious to know how generally it is in use by mariners and what is the accuracy of the results obtained with an ordinary sextant under the conditions that usually prevail for daylight observations at sea.

As magnetic observer and navigating officer on board the *Carnegie,* the Magnetic Survey Yacht of the Carnegie Institution of Washington, on her first cruise on the North Atlantic during 1909-1910, the opportunity came to me to try observing Venus by daylight. Observations for latitude were made on ten days at about 3 o'clock in the afternoon, with Venus on the meridian, in connection with observations on the sun for longitude. On two days observations were made at noon for longitude, in connection with observations on the sun for latitude. Also observations were usually made on two or more stars both in the morning and in the evening, so that we were able to determine very closely the accuracy of the results obtained from observations on Venus.

In observing on Venus the usual instruments and methods were employed that were used in making observations on the sun. The ordinary sun eye-piece was used in the sextant and all observations were made on the open bridge. In locating the star for the first time its approximate position with reference to the sun was found from the Nautical Almanac, and it was then very easily located with the naked eye. Instead of "bringing the star down" to the horizon, as is usually done with the sun, the method generally employed with stars was used, namely: Hold the sextant inverted in the left hand, then direct the eye-piece toward the star, and with the right hand "bring the horizon up" to the star by moving the index arm until the star and the horizon appear in the field of view together; then clamp the index arm and taking the sextant in the right hand as usual, direct it toward the horizon where the star will appear in position for observation. Or, when observing for latitude with Venus on the meridian, the sextant may be set to the proper reading by computing the approximate meridian altitude of the star from its declination and the latitude, which is known approximately, and then by sweeping the horizon to the south or north, as the case may be, the star will be located very easily.

The observations were usually made by two and sometimes by three observers, and the results never differed by more than 0.′5 of arc and usually agreed within 0.′1. On one day a fourth observer, who was not experienced in the use of the sextant, measured the meridian altitude of Venus, and his result differed by only 0.′7 of arc from the mean of the other results. So it is not a question of any particular skill or of any unusual atmospheric conditions, but merely requires a little patience and confidence and a normally clear atmosphere.

In the table of results is included the meteorological and other information usually noted when any astronomical observations were made. In determining the accuracy of the results obtained, the position as given by the Venus sight is compared with a mean position which depends upon observations made both before and after the Venus observations. In the case of the latitude the noon value resulting from observations on the sun is reckoned ahead to the time of the Venus sight, and the latitude resulting from observations on two or more stars in the evening is reckoned back to the time of the Venus sight, and the mean of these two reckoned results is compared with the value from Venus. On Dec. 9 this "dead-reckoning" had to be carried over a much longer interval, from star sights on the previous evening ahead to Venus, a period of twenty-two hours, and from sun observations at noon on the following day, back to Venus, a period of over twenty hours, differing by 4.′0 from the Venus value. This of course cannot be compared with the other results in the last column which depend upon dead-reckoning over a much shorter interval. In the case of the longitude the result from Venus is compared with a value which is the mean of the morning

DAYLIGHT OBSERVATIONS ON VENUS.

FIRST CRUISE OF THE "CARNEGIE," 1909–1910.

OBSERVATIONS FOR LATITUDE.

DATE 1909.	LATITUDE NORTH.	LONGITUDE WEST.	LOCAL APPARENT TIME.	WIND.		TEMPERATURE.		BAROMETER.	ATTACHED THERMOMETER.	HORIZON.	LATITUDE RECKONED.		MEAN.	LATITUDE BY VENUS.	DIFFERENCE MEAN—VENUS.	REMARKS.
				Direction	Force	Air	Water				From Noon	From P.M. Stars				
	° ′	° ′	h m			°	°	inches	°		° ′	° ′	° ′	° ′	′	
Dec. 9	21 06	34 16	15 25	S S E	0-1	24.2 C	23.8 C	30.10	78 F	Good	20 58.0*	21 06.7†	21 02.4	21 06.4	(—4.0)	* Reckoned from P.M. star sights on previous day, 22 hours earlier.
14	20 25	42 06	15 22	N N E	1	24.6	25.0	30.08	75	Good	20 26.9	....	20 26.9	20 25.0	+1.9	
16	20 04	46 03	15 20	N N E	3	23.7	25.0	30.10	76	Good	20 04.0	20 02.9	20 03.4	20 03.6	—0.2	
17	20 04	47 40	15 19	E	2	27.2	25.0	30.16	78	Rolling	20 02.6	20 03.9	20 03.2	20 03 7	—0.5	† Reckoned from noon on following day, 20½ hours later.
21	19 40	50 20	15 15	N W	2	26.2	25.8	30.21	80	Good	19 41.9	19 39.0	19 40.4	19 40.1	+0.3	
23	20 00	51 41	15 12	S E	2	26.0	25.6	30.26	80	Good	19 57.3	19 59.9	19 58 6	19 59.7	—1.1	
26	21 41	55 04	15 10	S E	3	26.6	24.9	30.17	79	Rough	21 39.6	21 40.6	21 40.1	21 40.8	—0.7	
29	24 06	59 40	15 03	S E	3	25.2	23.7	30.26	79	Good	24 04.5	24 07.3	24 05.9	24 06.4	—0.5	
30	25 25	62 03	15 00	S S W	5	24.0	23.7	30.16	78	Good	25 25.8	....	25 25.8	25 24.9	+0.9	Venus in hazy clouds.
1910 Jan. 3	28 09	66 57	14 55	N E	1	18.5	20.3	30.44	71	Good	28 09.0	....	28 09.0	28 09.0	0.0	
														Means	0.7 0.5	Omitting first. " " and second.

(* and † apply to Dec. 9 value only.)

OBSERVATIONS FOR LONGITUDE.

DATE 1909.	LATITUDE NORTH.	LONGITUDE WEST.	LOCAL APPARENT TIME.	WIND.		TEMPERATURE.		BAROMETER.	ATTACHED THERMOMETER.	HORIZON.	LONGITUDE RECKONED.		MEAN.	LONGITUDE BY VENUS.	DIFFERENCE MEAN—VENUS.
				Direction	Force	Air.	Water.				From A.M. Sun	From P.M. Sun			
	° ′	° ′	h m			°	°	inches	°		° ′	° ′	° ′	° ′	′
Dec. 18	20 01	48 02	12 00	Calm	0	29.0C	25.0 C	30.17	80 F	Good	48 01.1	....	48 01.1	48. 01.6	—0.5
1910 Jan. 3	28 03	66 48	12 00	N E	2	18.8	20.0	30.46	69	Good	66 47.5	66 48.3	66 47.9	66 48.5	—0.6

sun observations, reckoned ahead to noon, and of the afternoon sun observations, reckoned back to noon when the Venus observations were taken.

In the last column, omitting the first result because of the long interval over which the dead-reckoning had to be carried, the mean of the results is only 0.′7 of arc, and if we omit the second result, where no stars were observed in the evening, the mean is only 0.′5 of arc. When it is noted that while at sea the *Carnegie* is strictly a sailing vessel, using her auxiliary power only when becalmed, it is readily seen that the uncertainty in the steering, the difficulty in properly estimating the leeway and the effect of unknown currents, all tend to decrease the accuracy of the dead-reckoning. In view of this uncertainty the fact that the results from Venus differ in the mean from the value obtained by dead-reckoning by only from 0.′5 to 0.′7 of arc certainly indicates that uniformly good results can be obtained.

To the average mariner star sights appear difficult and more or less to be viewed with suspicion, but this really is due to a lack of familiarity with the operations involved, since they are no more difficult or complicated than for sun observations. The novelty of observing a star by daylight adds enough interest to the work of the navigator to warrant the undertaking of the operation without any further inducement, but there is added to this at least two opportunities for an accurate determination of the ship's position entirely independent of the operation of dead-reckoning.

It might be of interest to note the result of star observations with the sextant, using the sea horizon by moonlight. As the *Carnegie* lay at anchor off Funchal, Madeira, on Nov. 27, 1909, just one-half mile due south of a longitude station, the opportunity was taken to observe stars one night to determine the error of our chronometers. It was a bright moonlight night and the horizon was well defined. Altair was observed to the west and α Ceti to the east, and the results from the two stars differed by only 0.′1 second of time. The chronometer correction obtained differed from the accumulated correction, carried ahead from Falmouth time ball observations on November 9, by only 0.′2 second of time.

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